MOTION IMAGERY STANDARDS BOARD **Recommended Practice** **Digital Representation and Source Interface formats for Infrared Motion Imagery mapped into 1280 x 720 format Bit-Serial Digital Interface**	**MISB RP 0403.1** **01 February 2010**

1 Scope

The purpose of this document is to define a process needed for mapping digital infrared motion imagery parallel data from an IR source into a SMPTE 292M compatible serial digital interface. Two methods are described for formatting the infrared imagery. The first method pre-formats the imagery such that it is pre-scaled, pseudocolored, and prepared for display without further modification. The second method is geared toward retaining the original pixel values and therefore the full source dynamic range, up to 16-bits, of the infrared imagery.

This process maps various progressive 60Hz/50Hz infrared image formats into a progressive 60Hz/50Hz format based on a 1280 x 720 image lattice. Supported infrared formats covered by this document are 640 x 480, 640 x 512, 720 x 480, 1280 x 720, and 1024 x 1024, all at 60Hz and 720 x 576 and 1280 x720 at 50Hz. When utilizing the 1024 x 1024 image format, clipping will occur in the vertical frame dimension, resulting in a 1024 x 720 format. The IR source format mapping of 1920 x1080 is addressed in the Annex A and is beyond scope of this document.

2 Normative References

The following standards contain provisions, which through reference in this text constitute provisions of this recommended practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this recommended practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE 292–2006 - 1.5 Gb/s Signal/Data Serial Interface

SMPTE 296-2001 – 1280 x720 Progressive Image Sample Structure - Analog and Digital representation and Analog Interface

MISP Standard 0402 - Infrared Digital Signal format Interface for 8, 10, 12, 14, 16 bits – Bit-Parallel Digital Interface

MISP Standard 0404 – Compression for Infrared Motion Imagery

3 Introduction (Informative)

The purpose of this document is to define a standard broadcast format interface for the transmission of high bit depth infrared imagery. Infrared systems have traditionally utilized non-broadcast format interfaces due to bit-depths that are higher than what are defined in common broadcast formats. In addition, infrared cameras tend to be monochrome in nature as opposed to the color formats contained within many broadcast formats. To leverage commodity broadcast equipment, such as recorders, displays, and image compression systems, many IR systems have leveraged legacy RS-170 and NTSC analog interfaces. While these interfaces do provide connectivity, they provide a minimum level of quality for an end product that uses these interfaces. This recommended practice provides an option for improving the quality of infrared imagery when transmitted through a standard, broadcast format interface.

With the commercial market's adoption of the SMPTE-292M Serial Digital Interface, an opportunity is provided to leverage this digital interface to retain a higher level of quality for infrared imagery when compared to older interlaced analog formats. While other high bit depth interfaces exist, such as Firewire, GigE-Vision, and CameraLink, they are not readily found on a large percentage of commercial-off-the-shelf (COTS) broadcast equipment. As such, the formatting options outlined in this document provide a mechanism for transmitting infrared imagery, up to 16-bits, through the SMPTE-292M interface.

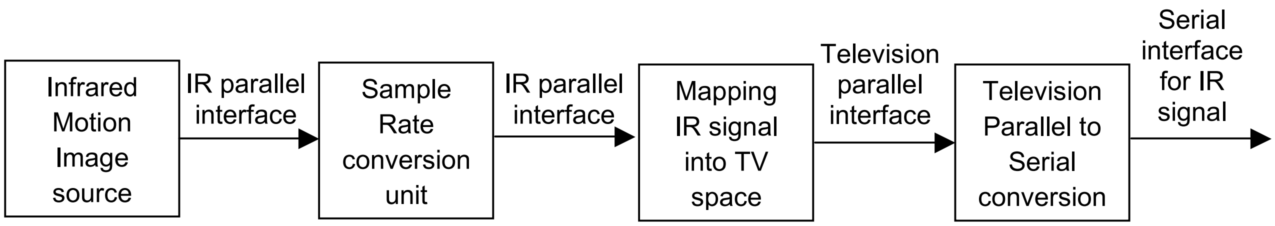
Two methods are described for formatting and transmitting monochrome infrared pixels through the standard 292M interface. The first method is geared toward providing an NTSC replacement interface for infrared cameras. In this case, the monochrome pixels are required to be converted into a scaled and pseudocolored format that is compatible with the standard 292M 10-bit YCbCr color format. This allows the images to be handled by standard equipment and then compressed, displayed, and/or recorded without further modification. The second method provides for transmitting the monochrome infrared pixels such that the full bit-depth, up to 16 bits, can be reconstructed on the back end of the interface. In this mode, feeding the signal directly into standard 10-bit YCbCr 292M devices, such as compression and display systems will result in artifacting due to the packing mechanism that is used to retain the full depth of the pixels. As a result, receiving systems for this method are required to reformat the pixel data before any processing or display of the pixels is carried out. For systems that are designed to work with this specific packing method, the ability to retain and leverage the full dynamic range of the source infrared imagery is retained. This allows for the use of compression systems that support higher bit depths, such as 14-bit H.264 Fidelity Range Extensions and JPEG2000.

An important aspect of signal delivery is the interface used between different devices that implement various types of processing. The specific interface parameters represent a "language" which allows connectivity between devices. While in the past a common television interface was based on transmission of analog values, today interfaces almost exclusively use digital processing, therefore eliminating any increase of noise during such processing.

Digital interfaces may be of parallel or serial type. Parallel interfaces use multi-conductor cables, while serial interfaces might use only one or two wires. The advantage of a parallel interface is its simplicity, however problems related to the cabling and signal propagation delays make this type of an interface relatively unreliable for longer (several 10's of feet) distances. A parallel interface is often used for definition of an image source and therefore this document describes the infrared signal source based on a parallel interface. To overcome the problem of transmission over longer distances, most modern television signal devices use some kind of a serial digital interface.

Television signal distribution systems, signal processing systems, and signal compressors (codecs) use serial digital interfaces. Due to the commonality of various television formats and their interfaces and the size of the television user market, the equipment manufactured for television users may be quite inexpensive and readily available in many countries all over the world.

To help the reader, the general processing scheme for an infrared signal that is contained in this document is shown below.



Major processing steps for IR-SDI interface

Before a parallel infrared signal may be converted into a serial digital stream used by television processing equipment, it is necessary to adapt the infrared signal to a signal format used by the television interface. This means that the sample rate of the IR signal shall be equal to the sample rate of the television equipment, and the IR signal is mapped into the relevant television signal interface space. Once these tasks are achieved, the resulting signal may be converted into a serial digital signal format and subsequently processed by television end-equipment, such as compressors, streamers, recorders, etc.

The television serial digital interface of interest within this recommended practice is defined in SMPTE-292M. This interface uses two transmission channels, each 10 bits wide, representing a 20-bit transmission channel. Therefore, there is sufficient channel space to allow for transmitting an infrared motion imagery word of up to 16-bits. When it is desired to retain the full dynamic range of the imagery, the IR sample word is required to be split into two 10-bit sample words which are passed through the television channel interface independently of each other via the luminance and color difference channels.

The IR source signals utilize the larger bit space provided by the combination of the luminance and color difference channels of the television interface by encoding the larger bit depth pixels as shown in this document. This method allows for interfacing with standard SMPTE-292M compliant equipment. The infrared imagery that is received through the 292M interface can then be handled appropriately depending on the pre-formatting and packing format method that has been chosen. For instance, many standard applications leverage an 8-bit 4:2:0 color format during compression. In this case, proper scaling and pseudocoloring is required before transmission into the compression device. It is also possible to process images in the 4:2:2 and 4:0:0 color spaces. To perform compression or processing at greater than 10-bits in the monochrome, the second method of packing the pixels is required. The possible compression implementations for the infrared imagery are independent of this recommended practice. Recommended formats for compression can be found in MISP Standard 0404.

This document is intended to provide guidance for formatting high bit depth infrared imagery into a format that is compliant with the SMPTE-292M interface. The approach outlined in this document is expected to provide high reliability, longer transmission distances, and a common equipment interface to existing commercial systems.

The document describes how an infrared signal from a suitable source of a 640 x 480, 640 x 512, 720 x 480, 720 x 576, 1024 x 1024 (with cropping to 1024 x 720) and 1280 x 720 line construct is converted to a common parallel interface (1280 x 720 at 74.25MHz), which is internally used by the interface conversion equipment and further converted to a serial digital stream using commonly available processing digital circuitry.

4 Infrared signal source description

Various formats exist for infrared imaging systems. The following sections outline common array sizes and resolutions and how these formats can be mapped into the 1280 x 720 pixel map space.

4.1 IR Digital Signal Source formats

An IR Digital Signal Interface provides a source of a progressively scanned infrared motion imagery signal. The infrared signal may be contained in one of the following formats shown in Table 1.

IR System	Infrared Image lattice	Frame rate	Number of lines per frame	Number of total samples/words per each line	Number of active samples/words of an IR image per each line	Pixel sampling clock
1	640 x 480	60 Hz	525	858	640	27.027 MHz
2	640 x 512	60 Hz	525	858	640	27.027 MHz
3	720 x 480	60 Hz	525	858	720	27.027 MHz
4	720 x 576	50 Hz	625	864	720	27 MHz
5	1024 x 720	60 Hz	750	1650	1024	74.25 MHz
6	1280 x 720	60 Hz	750	1650	1280	74.25 MHz
7	1280 x 720	50 Hz	750	1980	1280	74.25 MHz

Table 1 – Infrared motion imagery formats

4.2 Data bus for an IR Digital Signal source

4.2.1 Horizontal timing information of an IR digital system source

All of the IR image digital sources defined in this document shall use a parallel signal bus up to 16-bits wide. The logical values shall be referenced as positive logic. A high voltage state will be an asserted signal representing logical 1. A low voltage state will be a negated signal representing logical 0.

For synchronization purposes, a word sequence consisting of 3FFh, 000h, 000h, and XYZh called EAV (End of Active line) or SAV (Start of Active line) shall be used. The sample number format is shown in Figure 1 and Table 2 and the synchronization format is shown in Table 10.

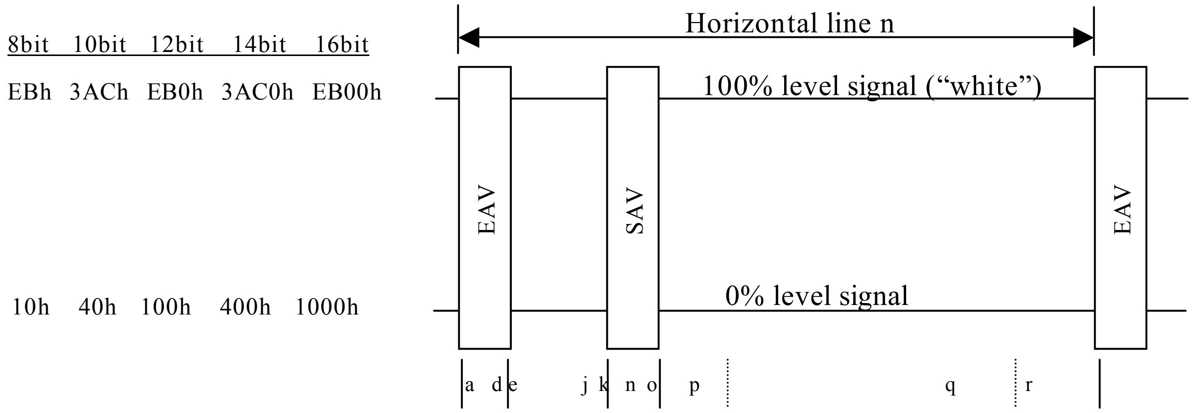


Figure 1 – Horizontal synchronization and sample numbering format

System	Clk [MHz]	Format	a	d	e	j	k	n	o	p	q	r
1	27.027	640x480	720	723	724	853	854	857	0	39	679	719
2	27.027	640x512	720	723	724	853	854	857	0	39	679	719
3	27.027	720x480	720	723	724	853	854	857	0	n/a	n/a	719
4	27	720x576	720	723	724	859	860	863	0	n/a	n/a	719
5	74.25	1024x720	1280	1283	1284	1645	1646	1649	0	127	1151	1279
6	74.25	1280x720	1280	1283	1284	1645	1646	1649	0	n/a	n/a	1279
7	74.25	1280x720	1280	1283	1284	1975	1976	1979	0	n/a	n/a	1279

Table 2 - Horizontal Sample number for different IR Image source

4.2.2 Output bus bit format

The data from the infrared imager shall be in a parallel word format up to 16 bits wide. Each data word shall represent a single pixel value. The acquired infrared image signal shall be uniformly quantized PCM at a relevant clock frequency as indicated in table 1.

Informative Note: Conversions for direct viewing of the digital infrared image from digital to analog domain, presume that post-filters which follow this conversion process provide a sin x / x correction that is complementary to the original sin x / x filtering of the acquired image during the analog to digital conversion. This is most easily achieved if, in the design process, the pre and post filter is treated as a single unit.

4.2.3 Dynamic range assignment of an IR signal source within a parallel output bit bus (Informative)[1]

Figure 2 indicates a general viewpoint for assignment of a dynamic range for an IR signal.

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[1] This section is informative, and does not constitute a normative part of this Recommended Practice. It is applicable to the display of an IR signal on legacy equipment.

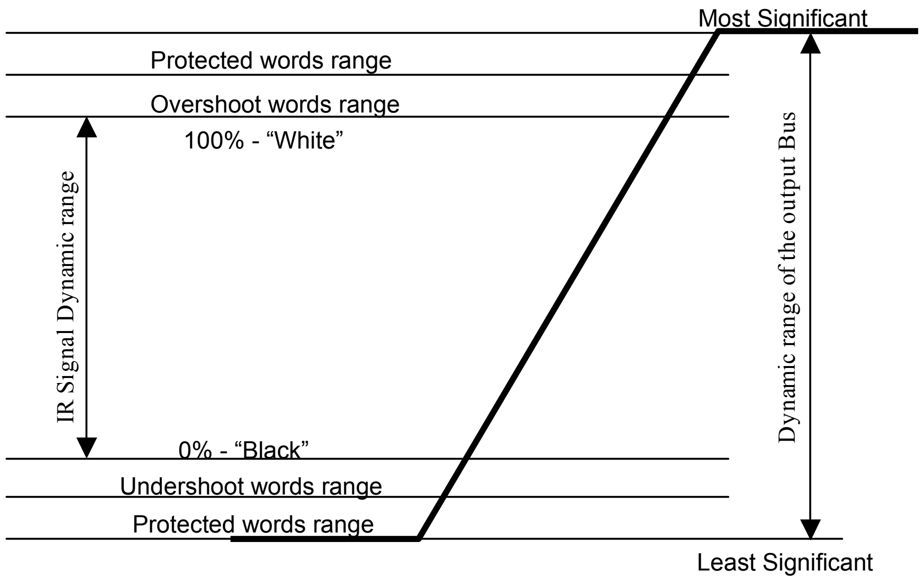


Figure 2 – Assigned dynamic range viewpoint

The maximum digital signal code for nominal IR illumination (“100% white”) and the minimum digital signal code for zero IR illumination (“0% signal = Black) shall be as shown in Table 3 for various output bus bit widths.

Bit range	8-bit (hex)	10-bit (hex)	12-bit (hex)	14-bit (hex)	16-bit (hex)
Most Significant	0xFF (255)	0x3FF (1023)	0xFFF (4095)	0x3FFF (16383)	0xFFFF (65535)
Protected words range	0xFF (255)	0x3FC-0x3FF (1020-1023)	0xFF0-0xFFF (4080-4095)	0x3FC0-0x3FFF (15041-16319)	0xFF00-0xFFFF (65280-65535)
Overshoot words range	0xEC-0xFE (236-254)	0x3AD-0x3FB (941-1019)	0xEB1-0xFEF (3761-4079)	0x3AC1-0x3FBF (15041-16319)	0xEB01-0xFEFF (60161-65279)
100% White signal level	0xEB (235)	0x3AC (940)	0xEB0 (3760)	0x3AC0 (15040)	0xEB00 (60160)
0% Black signal level	0x10 (16)	0x40 (64)	0x100 (256)	0x400 (1024)	0x1000 (4096)
Undershoot Words range	0x01-0x0F (1-15)	0x04-0x3F (4-63)	0x010-0x0FF (16-255)	0x40-0x3FF (64-1023)	0x100-0xFFF (256-4095)
Protected words range	0x00 (0)	0x000-0x003 (0-3)	0x000-0x00F (0-15)	0x0000-0x3F (0-63)	0x0000-0xFF (0-255)
Least Significant	0x00 (0)	0x000 (0)	0x0000 (0)	0x0000 (0)	0x0000 (0)

Table 3 - Digital range assignment for different word sizes on a parallel signal bus

Note 1: The Protected word ranges shown in table 3 are necessary to assure proper synchronization of the resulting IR image stream.
Note 2: The Undershoot and Overshoot words provide for a dynamic range needed by a filtered waveform to satisfy the Nyquist theorem.

5 Mapping process of the IR digital signal source into the parallel television interface space.

5.1 General information (Informative)

The reasons for mapping the parallel digital data onto a single transmission “wire” are twofold:

(i) A parallel interface is not capable of supporting a long transmission distance due to unacceptable skew of data over long distance (more than 10m).

(ii) Commonly used equipment (signal router, signal compressor, plasma and projector display) of the television industry uses serial digital interface connectivity. A device equipped with only a parallel interface is isolated and unable to readily interface with commercial television equipment.

The IR imager delivers in most cases progressively scanned motion imagery that is superior to interlaced scanned images used commonly in commercial television. However, television equipment is widespread all around and its use may be beneficial to the IR motion imagery.

The serial digital interface for television is a synchronous interface, meaning that a signal source digital clock and an interface digital clock are phase and frequency locked. While these clocks might have different frequencies, their relationship relative to each other is constant and time invariant. Based on this principle, the IR imagery clock of the IR source should also be synchronous with the IR serial digital interface (IR-SDI).

A typical television serial digital interface (SDI) interface supports three different signals; a signal representing the luminance of the image (Y) and two signals (Cr, Cb) representing color difference information of the image. The typical bit depth of a television image element (pixel) is 10 bits for each of the signal components at a frame rate of 30Hz. The color difference signals are sampled at a half of the sampling rate that is used for sampling of the luminance signal. As a result, the SDI interface bit rate (total bit throughput) is 270Mb/sec for 525-line component interlaced component scanned signal based on a 13.5MHz source clock. The payload capacity of such interface is even less.

In contrast as shown in Table 1, the IR imagery is based on a 60Hz frame rate, progressive scanning, up to 16-bit wide words and no color information. This leads to an interface requirement bit throughput of 432.4Mb/sec for the 16-bit signal. Such a high bit rate demands the use of the so called High Definition Serial Digital Interface (HD-SDI) for television, with a total bit throughput of 1.485Mb/s and payload capacity of about 1.1Gb/sec. The high definition television interface used for the IR digital motion imagery shall be based on the use of the HD-SDI image lattice set at 1280 x 720 pixels per frame, image parallel source clock at 74.25MHz with progressive scanning, frame frequency of 60Hz/50Hz and 750-lines in total for each frame. Details of this image format interface are located in the SMPTE-296M standard.

Figure 4 shows a possible process required for mapping of the IR source signal into an HD-SDI interface. The indicated process in Figure 4 is not unique, and serves only as an example. Different implementations are possible as well, however the parallel output signal from the proposed process shall conform to SMPTE-296M for system 1 or 3.

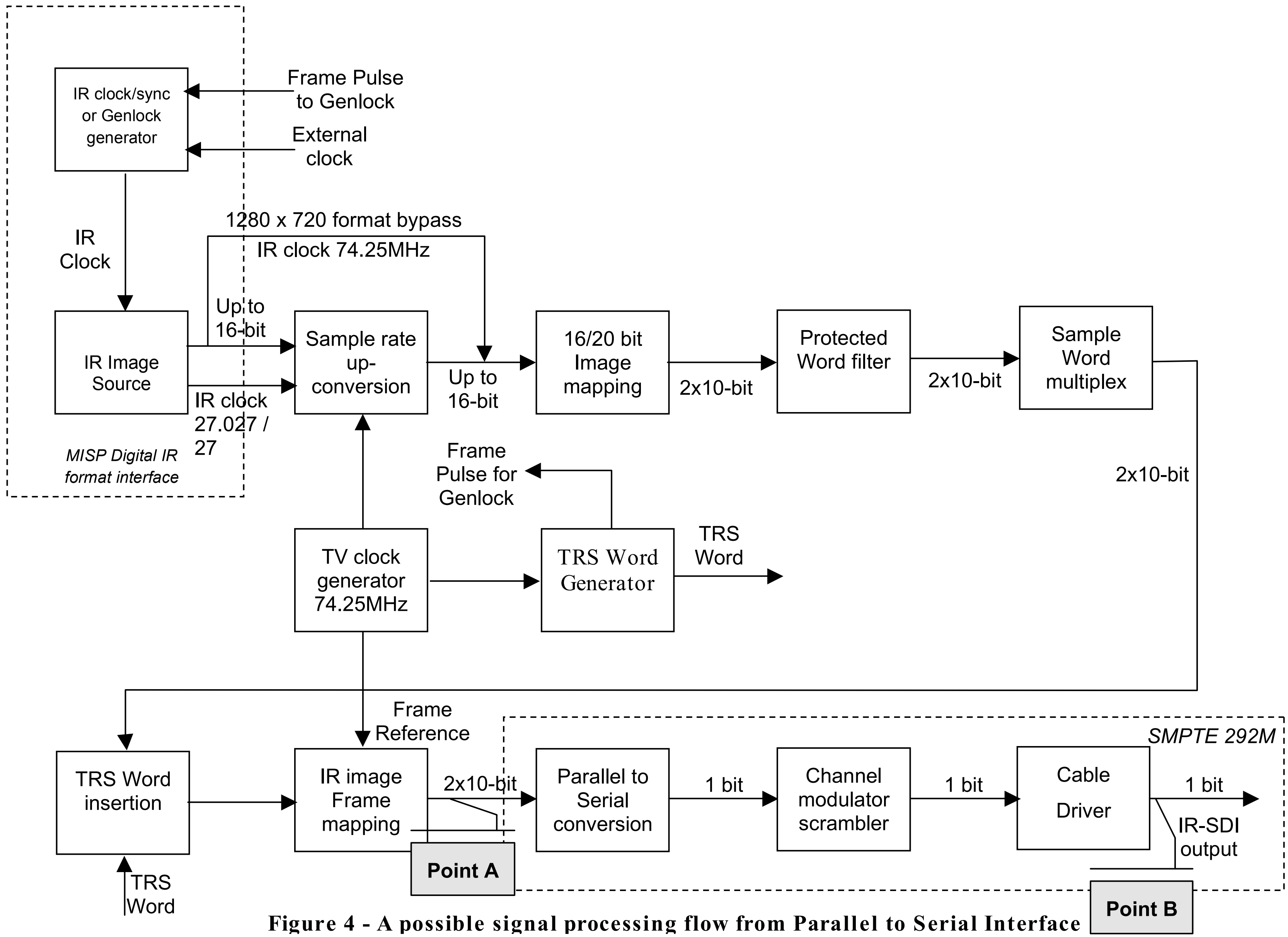


Figure 4 - A possible signal processing flow from Parallel to Serial Interface

5.2 IR clock generation and gen-lock.

Due to operational requirements, the IR source shall have two modes of operation, a self-sustaining mode and a gen-lock mode. The IR source clock in self-sustaining mode shall attain a frequency value for each frame frequency as indicated in Table 1, which shall be maintained to a tolerance of +/- 10ppm. The number of total samples of each line in a frame for each system shall be as shown in Table 1.

In the Gen-lock mode the IR clock may be synchronized periodically to an external stimulus consisting of:

(i) Vertical reset pulse
or
(ii) An external clock and a vertical reset pulse.

Other synchronization methods shall be acceptable, as long as the desired frequency lock with +/- 10ppm is maintained.

5.2.1 IR source clock signal description

The clock signal shall be a square wave of relevant frequency for each system as indicated in Table 1 and its waveform shown in Figure 3.

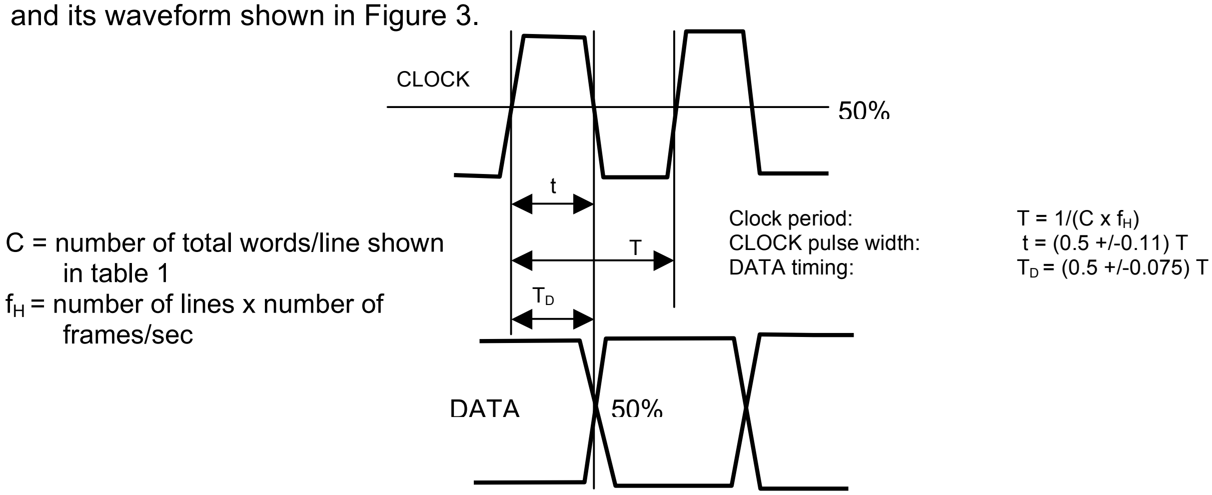


Figure 3 - Clock to Data timing

5.2.2 Clock jitter

The peak-to-peak jitter between rising edges shall be less than 0.08T measured over a period of one frame.

NOTE -- This jitter specification, while appropriate for an effective parallel interface, is not suitable for clocking digital-to-analog conversion or parallel-to-serial conversion.

5.2.3 Digital timing relationships of the 1280 x 720 television raster signal

Details of digital timing for a 1280 x 720 signal @ 60Hz and 50 Hz are found in the SMPTE-296M, Table 1, sections 4, 6, 7, and 8.

The applicable systems from the SMPTE-296M Table 1 are System 1 and System 3. Individual paragraphs in the SMPTE-296M standard that define the color processing are excluded from the application defined in this document.

5.3 IR image sample rate up-conversion

During the IR interface signal processing, the clocked IR image sample rate (system 1, 2, 3 and 4 from Table 1) shall be up-converted to a clocking frequency of a parallel digital Interface at 74.25MHz representing a 1280 x 720 system format. This process shall assure that both clocks (IR image clock and interface clock) are synchronous. The ratio by which these clocks (parallel Interface clock divided by IR Image clock) are locked together shall be (250 / 91) for 60Hz frame frequency, and (11 / 4) for 50Hz frame frequency.

After up-conversion, the number of IR image samples under the parallel interface system clock (74.25MHz) shall be identical to the number of acquired IR image samples under the image clock. The only difference is that the up-converted interface samples are distributed in time differently during the active line period of the parallel interface than they were in the active line period of the original IR scanned image.

The word values of the acquired IR image and the word values of the IR up-converted samples shall be identical to each other. The IR image samples of the acquired IR signal shall be located within the 1280 x 720 parallel interface system as shown in table 4.

System	IR Signal format	IR image system			Interface system (1280x720)		
		Number of total samples in each line	Number of active samples in each line	Location of IR samples in active line period	Number of total samples in each line	Number of active samples in each line	Location of IR samples in active line period
1	640x480	858	640	40 to 679	1650	1280	320 to 959
2	640x512	858	640	40 to 679	1650	1280	320 to 959
3	720x480	858	720	0 to 719	1650	1280	280 to 999
4	720x576	864	720	0 to 719	1980	1280	280 to 999
5	1024x720	1650	720	128 to 1151	1650	1280	128 to 1151
6	1280x720	1650	720	0 to 1279	1650	1280	0 to 1279
7	1280x720	1980	720	0 to 1279	1980	1280	0 to 1279

Table 4 – Horizontal location of IR source samples in the 1280 x 720 parallel interface system

Note: The indicated up-conversion process provides only for clock rate up-conversion and Table 4 indicates the location of the image samples on a horizontal line. The up-conversion process in the vertical direction is beyond the scope of this document. The mapping process and an up-conversion process are quite different from each other and the purpose of this document is to map the IR image into the high definition interface. The up conversion process commonly uses a sample buffer technique (several scanning lines long) with a dual clocking system and is beyond the scope of this document. In a practical sense, the displayed “rate up-converted’ image on a 16 x 9 high definition display device will be located in the center of the display but not filling completely the screen of the display device.

5.4 Mapping of an IR source image word (8 thru 16-bit) into the 292M interface channels

5.4.1 General information (Informative)

The television parallel system interface uses a time division multiplex to transport three different signal channels, Y, Cb and Cr, where Y is a luminance signal and Cb/Cr represents a color information signal. The IR image information contains up to 16-bits of IR light intensity signal and for the purpose of matching the IR signal stream to the television parallel interface, the IR signal will be split into two streams. For the first method where the infrared imagery is pre-scaled and pseudocolored to generate a displayable 4:2:2 format image, the infrared pixels are scaled to 10-bit intensity values and pseudocolored to generate the associated color information in the CbCr channel. For the second method where the unmodified full bit-depth pixels are desired on the back end of the interface, the upper 8 bits of the IR signal are placed in the luminance channel and the remaining lower IR bits are mapped into the color difference channel of the television interface. The reason for transmitting only the upper eight bits through the luminance channel results from the requirement to avoid the protected word ranges in the 10-bit interface.

5.4.2 High bit depth IR image mapping for the SMPTE-292M interface

Two specific methods are defined in this document for encoding 10 through 16-bit infrared image frames into the two channel, 10-bit interface defined by SMPTE-292M. The purpose for these two encoding methods is twofold. The first is designed to allow standard/legacy compression systems, without modification, the ability to compress, transmit, and display the encoded high bit-depth monochrome images, such that they will appear as properly scaled 8/10-bit monochrome or 24/30-bit pseudocolored images. In this case, it is important that contrast stretching of the source images occur before encoding and transmission through the 292M interface. Simply transmitting the upper 8 or 10-bits of a high bit-depth infrared image will generally result in poor image quality. Figure 4 shows the mapping, with clipping at the low and high ends to avoid the protected regions of the interface.

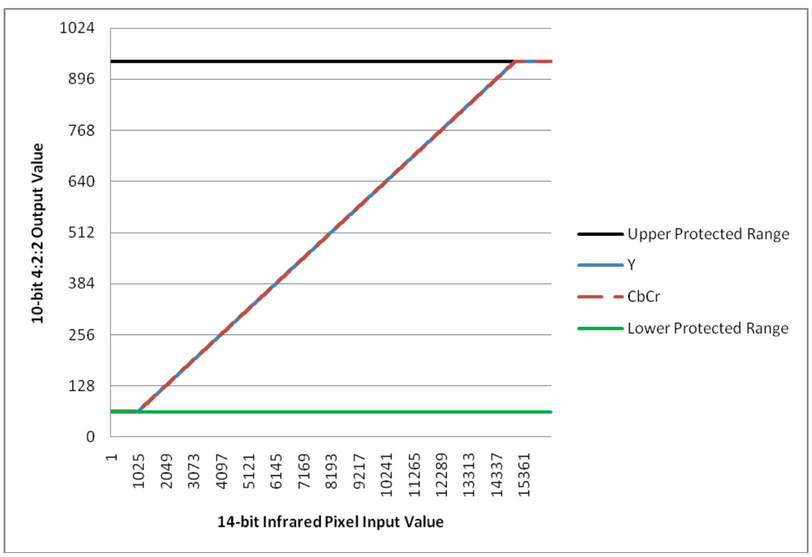


Figure 4: Encoding of 14-bit IR pixels into the SMPTE-292M luminance and color channels for standard compression and display applications

Figure 5 shows the basic flow diagram of how infrared pixels are scaled and pseudocolored in preparation for transport through the 292M interface when standard equipment is expected to be used on the back end of the interface. This method of operation constitutes the equivalent to how RS-170 and NTSC interfaces have been implemented on infrared cameras in the past.

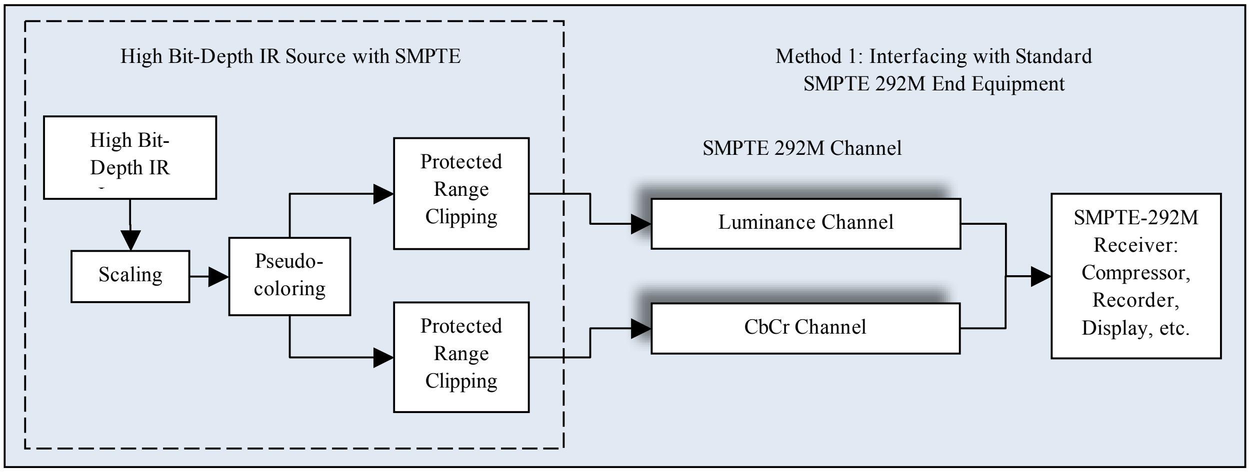


Figure 5: Block diagram of how 14-bit IR imagery is to be encoded for the SMPTE 292M interface.

Figure 6 shows how a legacy MPEG2 or an 8-bit 4:2:0 H.264 compression system would receive, process and compress the infrared video data of Method 1 from the SMPTE-292M interface. In this case, the top eight bits of the luminance and color channel data are processed in a manner consistent with any standard SMPTE 292M signal.

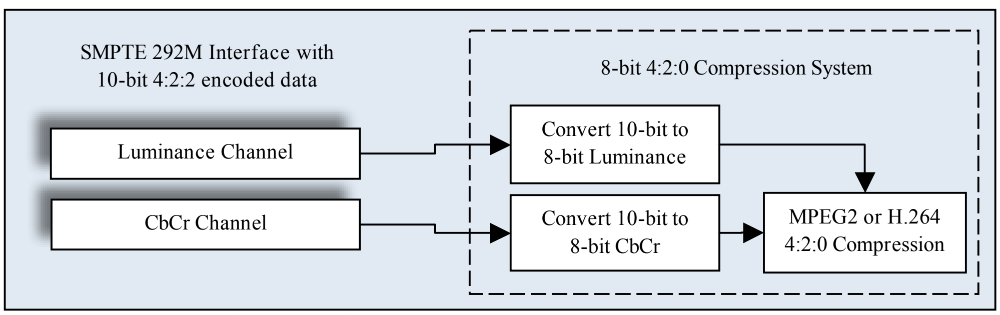


Figure 6: Block diagram of an MPEG2 4:2:0 compression system interfaced to a 292M interface.

For systems that are designed to take full advantage of high bit-depth pixels, the upper eight bits in the monochrome channel can be recombined with the remaining lower bits from the color difference channel on the receiving end to recreate the original high bit-depth pixels, without error. In this case, contrast stretching and pseudocoloring are not performed before transmission through the interface. With all high dynamic range bits available after compression, the end user has the flexibility of applying any desired contrast stretching before applying the pixels to a display or compression system. Transmission and reconstruction of high bit depth levels allows for implementation of MISP Standard 0404 compliant 14-bit H.264 or JPEG2000 compression using the interface.

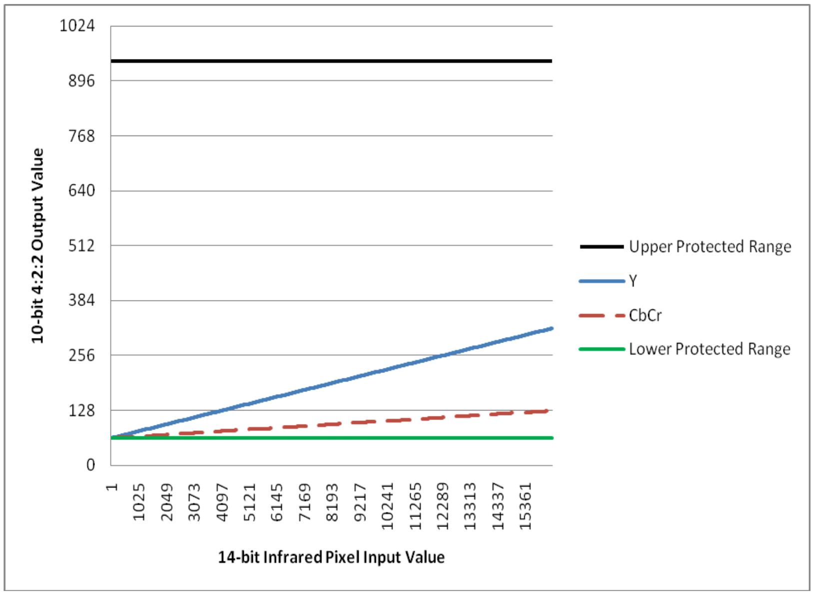


Figure 7: Encoding of 14-bit IR pixels into the SMPTE-292M luminance and color channels when the original 14-bit values are to be retained

Figure 7 shows a plot of the defined mapping for a 14-bit pixel input space into the two SMPTE-292M Y and CbCr channels when the original 14-bit values are required to be retrievable on the back end of the interface. An offset of 64 is applied to both channels to ensure that the transmitted values do not violate the lower and upper protected word range of the 292M interface. The lower protected range is defined to be between 0 and 63 and the upper protected range is defined to be between 941 and 1023. The receiving system is required to subtract the offset value of 64 from each channel before re-merging the upper and lower portions of the original source pixel value. The clipping of the luminance channel on both the low and high ends is due to the 10-bit codeword requirements specified in SMPTE-296M and discussed elsewhere in this document. Figure 8 shows a block diagram of how this second method of transmitting high bit-depth infrared imagery is conceptually implemented.

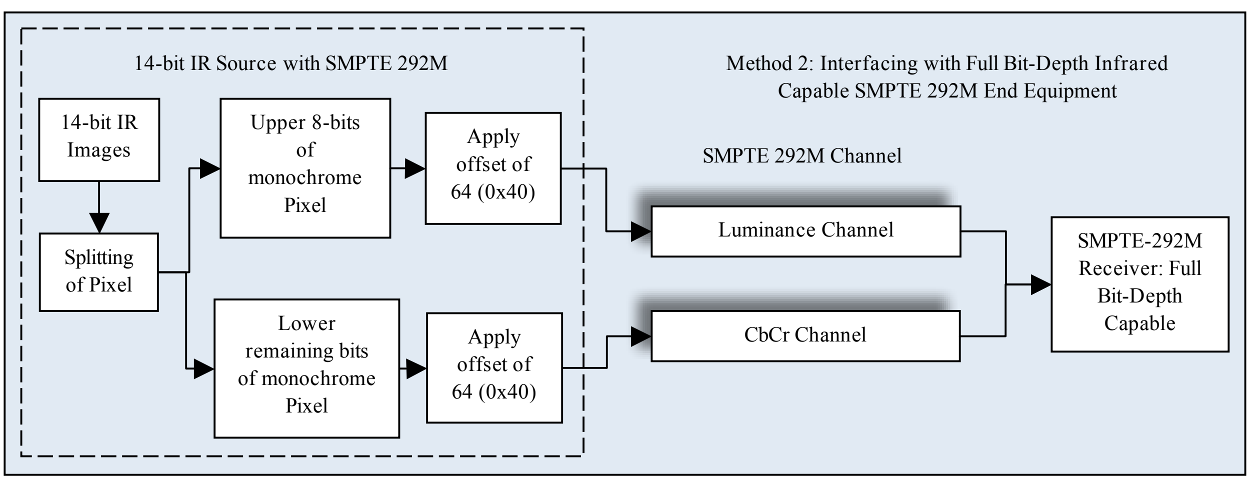


Figure 8: Block diagram of how high bit-depth IR imagery is to be encoded for the SMPTE 292M interface when the original 14-bit values are to be retained.

Figure 9 shows how a high bit-depth receiver that is compliant with Method 2 receives and processes the infrared video data from the SMPTE-292M interface. In this case, the offset of 64 is first subtracted from the 10 bit values of the luminance and color channel. The lower eight bits of the resultant luminance and color channel data are captured. The luminance value is then shifted and placed “on top” of the 8-bit color channel value, resulting in a 16 bit value that contains the original infrared pixel that is shifted to the MSB of the 16-bit word. This 16-bit pixel value can then be scaled and processed as desired.

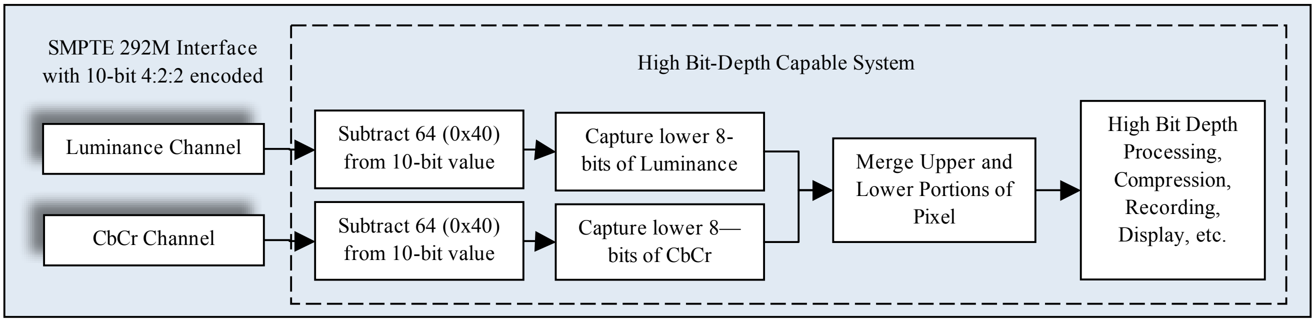


Figure 9: Block diagram of a high-bit depth handling compliant receiver system.

MISP Standard 0404 contains information for the specifics on the compression options that are available for infrared image data. H.264 FRExt 4:0:0 is the preferred compression codec for processing infrared imagery with bit-depths up to 14-bits. JPEG2000 is also allowed as an alternative to H.264 for the compression of high bit-depth infrared imagery.

5.4.3 Contrast Stretching

Various mechanisms exist for contrast stretching a 14-bit infrared image. These are typically based on algorithms such as plateau equalization, histogram projection, etc. The stretching is frequently performed on imagery before it is compressed or displayed to maximize the contrast of scene content. While contrast stretching is outside the scope of this document, the performance and utility of many systems will likely benefit by properly contrast stretching a high bit-depth IR image. In the first method that has been discussed, the contrast stretching occurs before the pixels are transmitted through the 292M interface. In the second method, if stretching is required, it will typically be performed after the high bit-depth pixels are received from the 292M interface.

5.4.5 Protected words

The IR Serial Digital Interface (IR-SDI) uses some words during the horizontal and vertical blanking interval for synchronization purposes. Out of the total available word range combination, 000h and 3FFh data words are used for synchronization purposes in 10-bit and 8-bit image transport systems. As indicated in table 3, data values 000h to 003h and 3FCh to 3FFh shall be excluded from the data stream. These values shall be eliminated from the mapped IR signal by filtering.

The filtering block indicated in figure 4 suggests that word filtering is done after sample rate upconversion. It is possible that filtering may be performed at a different stage of the process; possibly on the original IR image signal itself prior to sample rate up-conversion.

Note: A possible filtering method that might be used verifies mapped IR image words of both 10-bit channels for presence of the protected words, and when such words are found, the filter substitutes a fixed value nearest the original in the data range. As in a following example original words in range of 000h to 003h are assigned value of 000h; and original words 3FCh to 3FEh are assigned a value of 3FFh.

5.5 Timing and reference word (TRS) insertion

The IR Bit-Serial Digital interface shall use a combination of 000h and 3FFh words for synchronization purposes. These words shall be present on the 1280 x 720 parallel Interface and therefore must be inserted prior to the data word stream serialization process. A detailed description of the TRS (Timing and Reference Signal) system is in the SMPTE 296M standard. Abbreviated information is in section 4.7 of this document.

A synchronization pattern is based on so-called TRS words where combinations of four data words describe important timing signals. These groups of words are called Start of Active Video (SAV) or End of Active Video (EAV). Each SAV or EAV group consists of 3FFh, 000h, 000h word combination and an additional XYZh word containing protection bits and defining in detail other parameters as are Vertical Blanking interval, Horizontal Blanking interval, Ancillary space and Active video space.

5.6 Vertical and horizontal timing relationships for the 1280 x 720 system

5.6.1 Vertical timing of a digital stream

Figure 4 shows the vertical timing relationship of the 1280 x 720 system. In Figure 9 is shown the Vertical blanking area and a numbering scheme for line numbers as well.

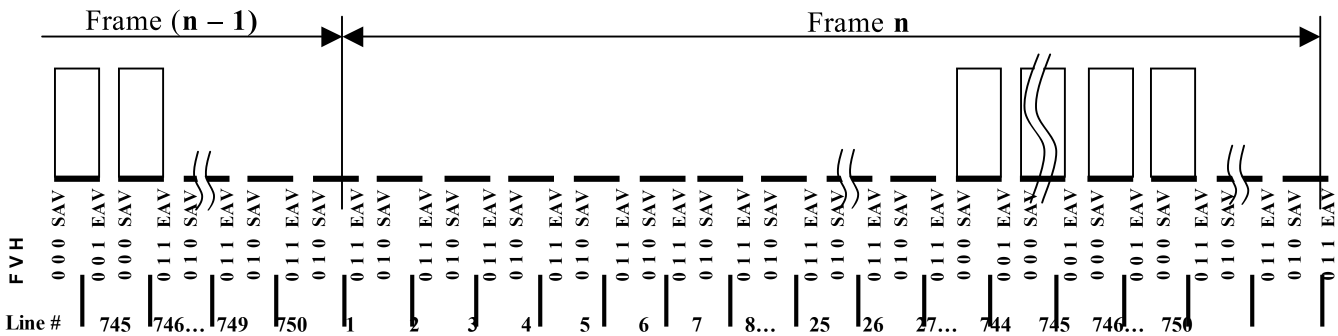


Figure 9 – Vertical timing of a digital stream

5.6.2 Horizontal timing of a digital stream (sample numbers) for 1280 x 720 system

A sample number identifies each horizontal sample in the 1280 x 720 system. Table 9 and Figure 10 show the numbering scheme of horizontal samples.

5.7 Timing reference signal description

Figure 10 and table 9 show the position of the timing reference signals (EAV, SAV) in the parallel multiplexed data stream. The timing reference signals are contiguous with the video data, when present, and continue through the vertical blanking interval as shown in Figure 9.

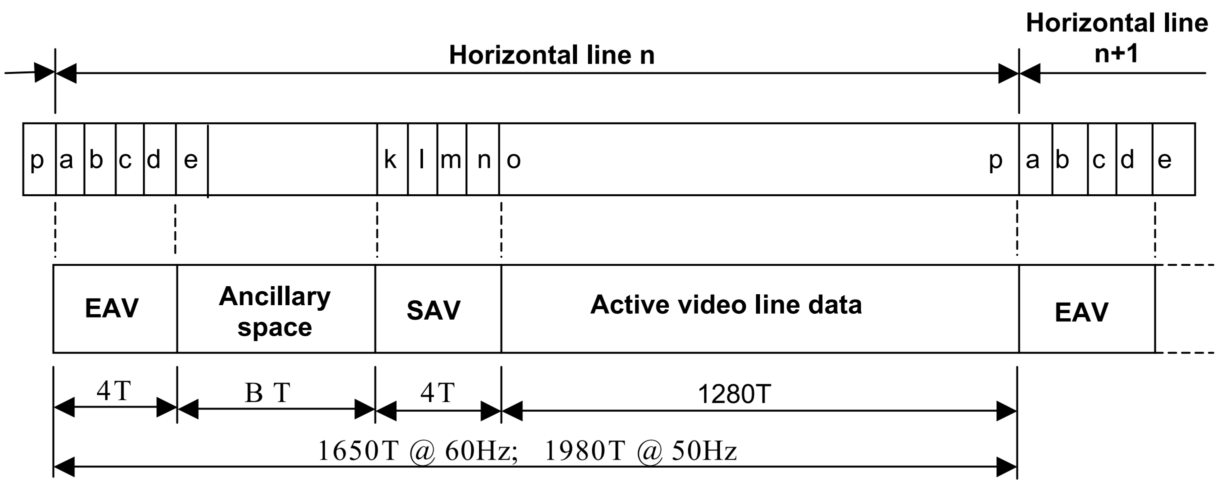
SMPTE 296M system	Frame freq.	Sample number (luminance channel)											
		a	b	c	d	e	k	l	m	n	o	p	a
1	60 Hz	1280	1281	1282	1283	1284	1646	1647	1648	1649	0	1279	1280
3	50 Hz	1280	1281	1282	1283	1284	1976	1977	1978	1979	0	1279	1280
		EAV				ANC space	SAV				Active video line		
		A horizontal line											

Table 9 – Sample numbering for a Horizontal line of a 1280 x 720 system

Each timing reference signal consists of a four-word sequence in the following format:

3FFh-000h-000h-XYZh

Due to existence of 8 and 10-bit equipment, for detection purposes all values in the ranges 000h-003h and 3FCh-3FFh must be considered equivalent to 000h and 3FFh as indicated in section 4.4.3. The first three words of the TRS are a fixed preamble. The fourth XYZh word shall contain information defining state of vertical blanking and horizontal blanking.



Note: T – reference clock period
BT – derived value

Figure 10 – Horizontal timing of a digital stream for a 1280 x 720 system

Assignment of bits within the fourth word is shown in table 6. An SAV sequence shall be identified by H = 0, and EAV sequence is identified by H = 1. In the progressive system the F bit shall be always set to 0 and V bit changes its state during vertical blanking (see Figure 9.). P0, P1, P2, and P3 (parity bits) have states dependent on states of bits F, V, and H according to table 10.

Bit number		b9 (MSB)	b8	b7	b6	b5	b4	b3	b2	b1	b0
Word	Value										
0	3FFh	1	1	1	1	1	1	1	1	1	1
1	000h	0	0	0	0	0	0	0	0	0	0
2	000h	0	0	0	0	0	0	0	0	0	0
3		**1**	**F**	**V**	**H**	**P3**	**P2**	**P1**	**P0**	**0**	**0**
	200h	1	0	0	0	0	0	0	0	0	0
	274h	1	0	0	1	1	1	0	1	0	0
	2ACh	1	0	1	0	1	0	1	1	0	0
	2D8h	1	0	1	1	0	1	1	0	0	0

Table 10 – Timing Reference codes and Protection bits for SAV and EAV

5.8 IR Image frame mapping into 1280 x720 parallel interface system

5.8.1 Frame mapping of 640 x480, 640x512, 720 x480 and 720 x 576 IR source image

The acquired IR image vertical size is based on 480 horizontal lines at 60Hz or 576 lines at 50Hz IR image structure. As such a mapping is required to achieve a centered position on the 1280 x 720 display screen, the location of the IR image lines shall be as indicated in Figure 11.

A simple mapping process may be achieved using a buffer capable of holding at least 576 lines up to a full frame of 720 lines. The specific implementation will depend on the implemented processing of the IR image prior to this step and might be implemented at various points of the processing chain.

The line numbers for a 720-line raster image contain active video from line 26 thru line 745, inclusive.

A 480-line structure, operating at 60Hz frame frequency, will have its lines located between line number 146 and line 626 inclusive, of the 720-line structure. A 512-line structure, operating at 60Hz frame frequency, will have its lines located between line number 130 and line 642 inclusive, of the 720-line structure.

A 576-line structure, operating at 50Hz frame frequency, shall have its lines located between line number 98 and line 674 inclusive, of the 720-line structure.

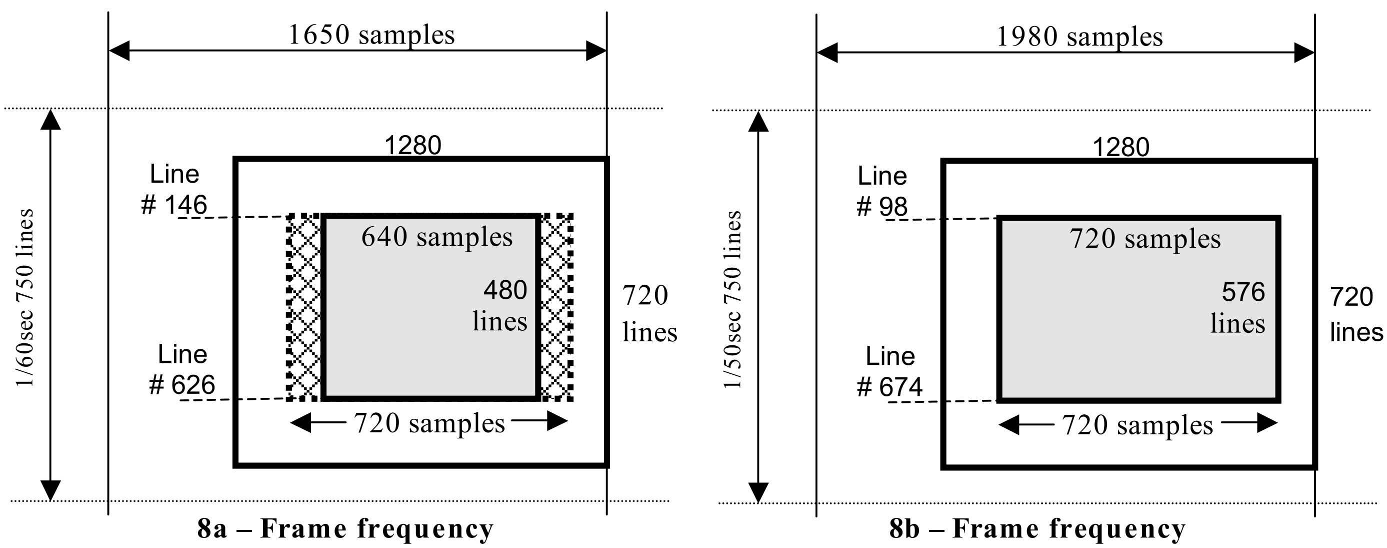


Figure 11 Positioning of IR image mapped lines in the 1280 x 720 lattice

5.8.2 Frame mapping of 1280 x 720 IR source image

Frame mapping of the IR Image source is not necessary due to the IR source signal occupying the full height of the 1280 x 720 system.

5.8.3 Frame mapping of 1024 x 1024 IR source image

Frame mapping of the IR Image source requires clipping in the vertical direction due to the IR image having more lines than is available within the 720p interface. 304 horizontal lines are required to be clipped from the source image as part of the frame mapping to the 1280 x 720 format frame.

5.9 Parallel to Serial conversion, channel modulation, cable driver

All parameters of the mapped IR parallel interface as indicated at point A of figure 4 shall be identical to parameters as defined in this document and conforming to SMPTE-296M for 720 line progressive signal system 1 and 3. The mapped IR signal is an input signal for implementation of a Bit-Serial Digital interface for IR imagery IR-SDI.

Bit-Serial Digital interface output of an IR motion imagery interface shall be compliant to SMPTE-292M, table 1 system L as indicated at point B of figure 4.

6 Annex A (informative)

6.1 Mapping of IR motion imagery format 1024 x 1024 and 1920 x 1080 at 60Hz.

Mappings of IR motion imagery progressive formats 1024 x 1024, 1920 x 1080, at 60Hz up to 16 bits, without windowing, into the SMPTE-292M Bit-Serial Digital interface is beyond the capacity of the IR-SDI interface described in this document. A potential solution for these implementations involves the use of the dual SMPTE-292 link (SMPTE-372M), which is beyond the scope of this document.

7 Annex B (Informative)

7.1 Identification of mapped IR image format

SMPTE-352M provides for identification of video payloads in a serial digital interface. While this document provides a very specific and unusual video payload mapping not covered by the SMPTE-352M, it would be possible to use the SMPTE-352M method that inserts ancillary packet into the serial digital stream identifying the IR imagery specific payload. The specific implementation of such an ancillary packet (SMPTE-291M) is beyond scope of this document and requires separate attention.

8 Bibliography <optional>

SMPTE 352–2000 – Video Payload Identification for Digital Television Interfaces

SMPTE 274-1998 – 1920 x1080 Scanning and Analog and Parallel Digital Interfaces for multiple picture rates

SMPTE 291–1998 – Ancillary Packet and Space Formatting

SMPTE 372–2000 – Dual Link 292M Interface for 1920 x 1080 raster